



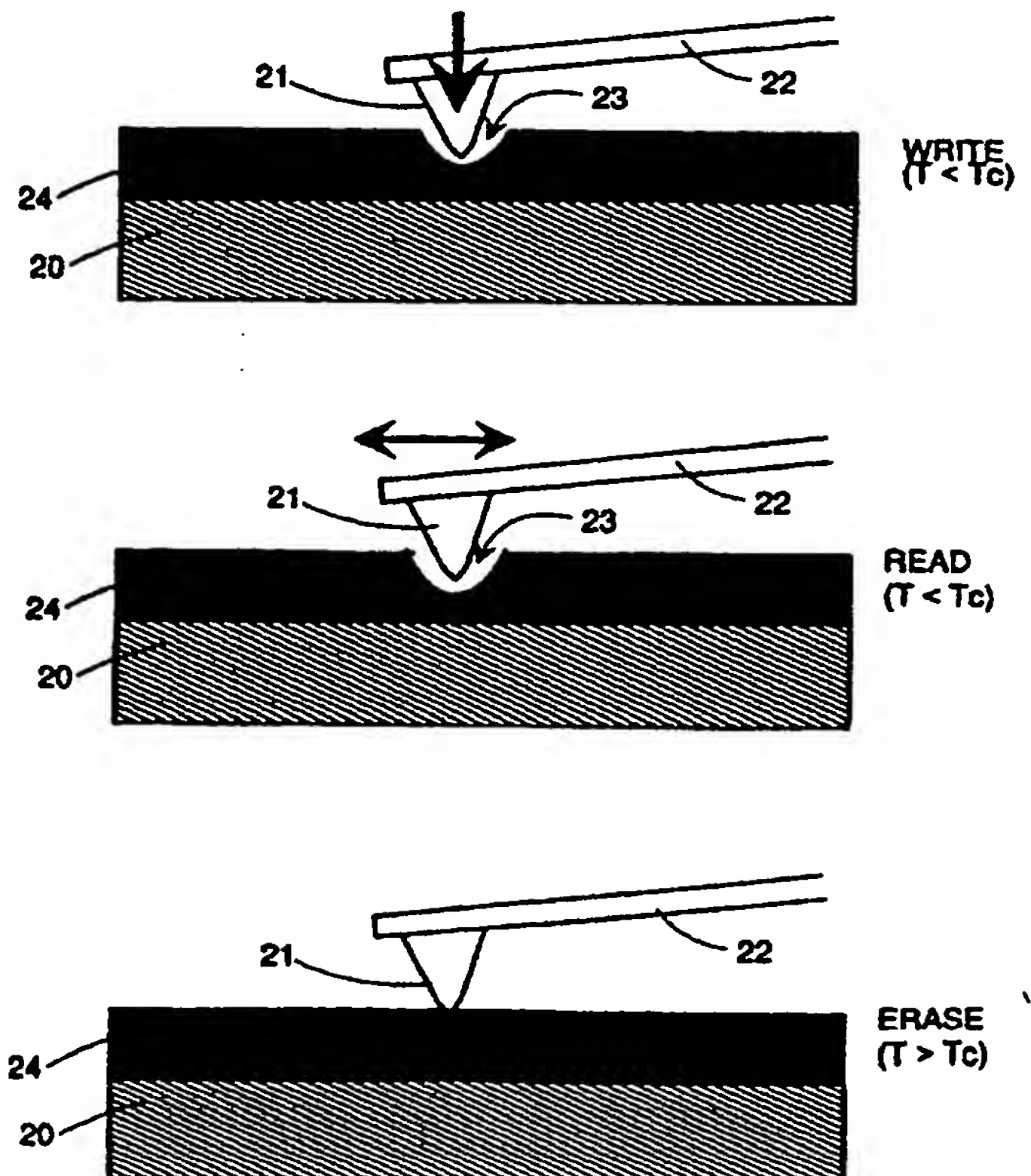
INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(54) Title: SHAPE MEMORY ALLOY RECORDING MEDIUM, STORAGE DEVICES BASED THEREON, AND METHOD FOR USING THESE STORAGE DEVICES

(57) Abstract

The present invention concerns a storage medium for scanning probe storage devices. This storage medium comprises a substrate (20) carrying a shape memory alloy layer (24). The shape memory alloy layer (24) is chosen such that an indent (23) can be formed by mechanically deforming said shape memory alloy layer (24), if a local probe (21, 22) of said scanning probe system exerts pressure on said alloy layer (24). An indent (23) can be removed by locally heating said shape memory alloy layer (24) to its transformation temperature (T_c) or above such that the shape memory alloy returns to its Martensite form.



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DESCRIPTION**Shape Memory Alloy Recording Medium, Storage Devices Based Thereon,
And Method for Using These Storage Devices****TECHNICAL FIELD**

10 The present invention relates to shape memory alloy storage media, storage devices based on these storage media, and methods for operating these devices.

BACKGROUND OF THE INVENTION

15 Improvements in semiconductor processing techniques have led to drastic reductions in the size of today's computers. However, while the microprocessors, displays and other components are getting cheaper and smaller, the bulk data memory units limit the overall size reduction. For
20 further reduction in size and power consumption the conventional disk drive storage systems need to be replaced by small, high capacity storage devices.

There is a demand for storage devices having storage capacity of more than
25 1 Terabit. Further criteria for such storage devices are: power consumption, overall weight and size, reliability, data security, and shock resistance (if used in portable computer systems).

With a storage device which combines the capacity of a rotating memory
30 with the speed, size, power consumption and reliability of solid state memories, computers would take another quantum leap in performance and compactness.

1 The development of scanning tunneling and atomic force microscopes has led to first storage systems which make use of local probes.

5 A scanning tunneling storage system has been proposed in the European patent EP 247219, for example. This system comprises current detectors being attached to an array of cantilevers. A storage medium is placed opposite to the array. The storage medium is displaced by means of a two-dimensional piezoelectric positioning device. There is no adequate approach for erasing of information disclosed.

10 In US patent 5,307,311 a memory device is described which makes use of a very large set of independently operating subdevices. It employs an array of hundreds of microcantilevers having an area in which bits are stored. Opposite to these cantilevers there are hundreds of read/write heads which
15 are similar in nature to scanning tunneling or atomic force microscope scanning tips. Each cantilever is moved in an oscillatory manner such that the respective read/write head scans over the bits stored thereon.

It is essential for a storage device that information can be recorded (WRITE),
20 retrieved (READ) and deleted (ERASE). In particular in case of scanning probe storage systems which have been developed so far, no reliable and satisfying erase technique has been proposed. Recent material investigations have revealed special materials which are in principle suitable as erasable storage medium. However, steps required to erase
25 information being stored in such a material are either too slow, or cannot be controlled properly to facilitate erasure of single bits within a storage medium. There is currently no storage medium known, which satisfies the needs for use in scanning probe storage devices.

30 A typical example of a scanning probe storage device and the mechanism for data recording is addressed in the US patent 4,916,688. The storage medium comprises a state-transformable material. Current pulses induced by voltage pulses sufficient to selectively heat discrete areas of the

1 state-transformable material are applied to a STM tip. If one cools the
state-transformable material after local heating the electronic properties are
locally altered. These locally altered areas can be detected (READ) using a
STM tip and sensing the tunneling current between storage medium and tip.

5 In view of the disadvantages of known media suitable for use in scanning
probe storage systems there is a need for improved materials and storage
concepts in particular to overcome the known problems. The high
resolution available through the application of a STM or AFM is certainly a
10 most desirable attribute. However, for purposes of mass data storage, the
storage medium as such requires additional attention.

It is an object of the present invention to provide a new and improved
storage medium for storage system, and in particular for scanning probe
15 storage systems.

It is an object of the present invention to provide a method for storing,
retrieving and erasing from such a storage medium

20 It is a further object of the present invention to provide new storage devices
being enabled by the new storage medium, or making use of the new
storage medium.

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SUMMARY OF THE INVENTION

This has been achieved by the provision of a storage medium having

- a shape memory alloy (SMA) layer and
- a substrate carrying the SMA layer,

both being arranged such that information can be recorded (WRITE) by mechanically forming an indent in the SMA layer, e.g. by means of a scanning probe tip. The information recorded in form of indents in said SMA layer can be read by scanning the surface. Either an AFM, or a STM scanning probe or probe array can be used for the retrieval of information. Information can be erased from the new storage medium by locally heating the SMA layer above its transformation temperature (T_c). This can either be done by means of a scanning probe being heated such that it serves as heat source for locally heating the SMA layer, or a light pulse may be applied being suited to locally raise the SMA temperature beyond its transformation temperature T_c .

DESCRIPTION OF THE DRAWINGS

The invention is described in detail below with reference to the following schematic drawings:

5

FIG. 1 shows a conventional scanning probe storage system.

10

FIG. 2 shows a cross-section of a storage medium comprising a shape-memory-alloy (SMA) layer, according to the present invention.

15

FIG. 3A shows a cross-section of a storage medium being similar to the one shown in Figure 2 and a scanning probe exerting pressure on the medium such that information is stored in form of an indent.

20

FIG. 3B shows a cross-section of a storage medium and a scanning probe moved across the storage medium for reading the information stored by detecting indents.

FIG. 3C shows a cross-section of a storage medium and a scanning probe, where an indent is removed by locally heating the region close to the indent using a local probe.

25

FIG. 4A shows a cross-section of another storage medium comprising a thin shape-memory-alloy (SMA) layer, according to the present invention.

30

FIG. 4B shows a cross-section of the storage medium of Figure 4A and a scanning probe exerting pressure on the medium such that information is stored in form of an indent.

1 **FIG. 5** shows a cross-section of another storage medium comprising a
thin shape-memory-alloy (SMA) layer, according to the present
invention.

5 **FIG. 6** shows a cross-section of another storage medium having
several storage fields each comprising a shape-memory-alloy
(SMA) layer, according to the present invention.

10 **FIG. 7** shows a schematic view of a scanning probe storage system
having a local probe array positioned opposite to a storage
medium as shown in Figure 6.

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GENERAL DESCRIPTION

It is shown in the following that shape-memory-alloys, if employed in an appropriate manner, can be used for making new storage media. These storage media are particularly well suited for use in connection with scanning probe storage systems.

Before addressing specific embodiments of the present invention, the underlying physical effect and the characteristic behavior of SMAs are described and examples of suited SMAs are given.

Shape-Memory-Alloy:

A SMA is a material which changes its shape in a reversible manner if heated or cooled appropriately. SMAs undergo a transformation in their crystal structure when cooled from the stronger, high temperature form (referred to as Austenite form) to the weaker, low temperature form (referred to as Martensite form). An SMA in Martensite form can be easily deformed to a new shape. If one now heats this SMA to a temperature above its transformation temperature (T_c), it automatically reverts to its Austenite form going back into its previous shape with great force. This process can be repeated millions of times without the material changing its properties. I.e., the SMA resumes the shape prior to its deformation when being heated to the temperature T_c or higher. The SMA does not change its shape when returning into the Martensite form by cooling.

The transformation temperature T_c depends on the composition of the SMA and other factors. The temperature T_c can be anywhere between 0 and 100 degree C. In certain cases the transformation temperature is even higher. The SMA and its composition should be selected such that it is suited for use in connection with the present invention. It is also important, that SMA materials are known which are extremely corrosion resistant (e.g. Ni-Ti compositions). This is of particular interest in connection with the present invention, because corrosion may cause problems at the surface of a

1 storage medium leading to loss of data or an increased signal-to-noise ratio
when retrieving information.

Typical examples of SMAs are alloys based on: Cu-Zn-Al, Ti-Ni such as the
5 binary Ti-Ni thin films or the ternary shape memory alloys Ti-Ni-Cu and
Ti-Ni-Pd, Fe-Mn-Si, Fe-Ni, Cu-Al-Ni, Ti-Ni-Hf, Au-Cd, Cu-Al-Be, or a
quaternary alloy such as Ni-Al-Fe-Mn, or Ti-Pd-transition metal based alloys.
Further examples are given in "Fundamentals and Industrial Technology of
Copper and Copper Alloys", Japan Copper Drawing Association, published
10 May 1988, and other publications.

SMA alloys in form of thin films or thicker layers can be formed using
sputtering and evaporation techniques, for example. Also suited are
Vacuum Induction Melting or Vacuum Arc Remelting techniques. Since the
15 transformation temperature T_c of the various SMAs depends on the
composition of the alloy, it is indispensable to have an accurate control of
their composition. Well suited for making such alloys is the RF (radio
frequency) sputter deposition technique because it allows to control the
composition to a sufficient extent.

20 A cross-sectional view of the basic structure of a new storage medium in
accordance with the present invention is illustrated in Figure 2. The storage
medium at least comprises an SMA layer 24 and a substrate 20 being
sufficiently rigid to carry this SMA layer 24. The thickness of the SMA layer
25 is typically between 1nm and 10 μ m, and preferably between 10nm and
500nm, whereas the substrate has a thickness of a few hundred μ m and
more. Preferably, the thickness of the SMA layer should be about 1/2 of the
maximum diameter of an indent 23, or thicker. I.e., if the indent has a
diameter of 15nm, for example, the SMA layer 24 should be 7.5nm or
30 thicker.

1 A scanning probe storage system, as hereinafter addressed, comprises at least one scanning probe. Such a scanning probe may consist of a cantilever 22 and a tip 21, as for example shown in Figure 3A.

5 The operation of a scanning probe storage system, and in particular the different modes of operation, namely WRITE, READ and ERASE, are illustrated in Figures 3A through 3C.

The WRITE process is described in connection with Figure 3A. In order to
10 write information into the medium, indents 23 are formed mechanically. This can be done by means of a local probe 21, 22, or local probe arrays. If a force is applied to the local probe, the local probe deforms the surface of the SMA layer 24 such that an indent 23 is formed. The size and shape of such an indent 23 depends on the shape of the tip 21 of the local probe, the
15 angle between local probe and storage medium, and, last but not least, the composition of the SMA. It is important to note that information is written into the medium at a temperature below the transformation temperature T_c . SMAs turned out to be fairly soft at temperatures below T_c and a contact pressure of a few hundred micro Pascal is sufficient to locally deform the
20 SMA layer. With an AFM tip, for example, pressures of 10 Pascal and more are easily achieved.

Data can be stored in said medium in form of a sequence of small indents (pits), for example. If one employs a suited coding scheme, the information
25 may be compressed, or the signal-to-noise ratio at retrieval may be improved.

The information stored in the new storage medium can be retrieved by means of a single scanning probe or a scanning probe array. In Figure 3B,
30 a single probe 21, 22, scanned across the surface of the SMA layer 24, is illustrated. There are various modes of operations of such scanning probes known in the art. In principle, any method being suited to detect small variations in the surface of the storage medium are also suited for use in

1 connection with the present invention. Crucial is the resolution which can be
obtained (the better the resolution, the more data can be stored on one and
the same storage medium), and the velocity at which data can be read, the
robustness of the local probe (wear-out and damage of the probe limits the
5 reliability of the whole storage system), just to name some important
aspects.

If the stored information is retrieved using a scanning probe operated in
contact mode, for instance, the pressure exerted on the SMA layer 24
10 should be smaller than the pressure applied when writing indents. One may
use a tip of different shape, size, or material when reading information, for
example. The cantilever structures disclosed and claimed in the co-pending,
unpublished PCT patent application PCT/IB 96/00209, are well suited. The
larger tip of a cantilever structure disclosed in the co-pending patent
15 application can be used for reading information, whereas the smaller tip can
be used to write information.

In Figure 3C, it is schematically indicated how an indent 23 can be
removed. As described further above, a shape memory alloy returns to its
20 original form (Martensite form) with great force if it is heated to the
transformation temperature or higher. A local deformation 23 can thus be
removed by locally heating the SMA layer 24 such that the transformation
temperature is reached or exceeded. As soon as the transformation
temperature is reached, the SMA layer 24 returns to its Martensite shape
25 (shown in Figure 2). The indent 23 is completely removed. This process can
be repeated millions of times without leaving any marks or indications that
there was an indent. This is very important, because information can be
rewritten many times without having to deal with increased noise level, or
shifted detection thresholds.

30

In the example illustrated in Figure 3C, the tip 21 of a local probe is
employed to locally heat the SMA layer 24. For this purpose, the cantilever
22 or the tip 21 can be heated either directly or indirectly such that heat is

1 transferred into the SMA layer 24. Heat from the local probe can either be transferred by radiation if the tip 21 is positioned at close range, or it may be transferred from the tip 21 into the SMA layer by bringing it into contact.

5 Instead of using a local probe to erase the information, a light pulse may be directed right onto the indent 23. The intensity of such a light pulse has to be sufficient to locally raise the temperature such that T_c is reached or exceeded. If the substrate 20 is conductive, a current of sufficient density between the tip 21 and the substrate serving a back-electrode can be used
10 to heat the SMA locally.

Another storage medium according to the present invention is illustrated in Figure 4A. This storage medium comprises a thin SMA layer 34 being carried by a substrate 30. It is illustrated in Figure 4B how information is
15 recorded. The tip of a scanning probe, for example, exerts pressure onto the thin SMA layer 34 such that also the underlying substrate 30 is deformed. The thickness of the SMA layer 34 and the substrate material are chosen such that firstly, indents can be formed which extend into the substrate, and secondly, these indents can be removed by local heating in a
20 manner that not only the SMA layer 34, but also the substrate underneath return into its original shape. If the substrate is sufficiently soft, the SMA layer, when returning into the Martensite form, pulls the substrate back into the normal shape. The thickness of the SMA layer 34 is between 1nm and 1 μ m, and preferably between 1nm and 100nm.

25

The present storage media can be further modified by adding additional layers underneath or on top of the SMA layer. In Figure 5, a layered storage medium is shown which comprises a substrate 40 covered by a soft layer 41 and a thin SMA layer 44. As in Figure 4B, indents are formed by
30 mechanically deforming the SMA layer 44 and the soft layer 41 underneath. In the embodiment the substrate 40 is not deformed at all.

1 In another embodiment, the SMA layer may be covered by a mono-layer of molecules, e.g. alkanethiol chain molecules. This mono-layer then serves as kind of a lubricant reducing the friction between the scanning probe and the storage medium.

5 The basic elements of scanning probe storage systems are described and claimed in co-pending PCT patent application PCT/IB 95/00594. The details of this patent application are herewith incorporated by means of reference.

10 Another embodiment of the present invention is described in connection with Figures 6 and 7. In Figure 6, a cross-sectional view of a storage medium with several storage fields 54.1 - 54.4 is shown. Each storage field 54.1 - 54.4 consists of an SMA layer. These SMA layers are carried by a common substrate 50. A scanning probe storage system in accordance with
15 the present invention, further comprises local probe array with cantilevers 52.1 - 52.4, as illustrated in Figure 7. Each cantilever carries at least one tip for interaction with the storage fields 54.1 - 54.4 of the storage medium. The array of cantilevers with the respective tips is scanned as a whole over the corresponding storage fields 54.1 - 54.4 and the data in each storage field
20 are addressed quasi-simultaneously. In addition to this lateral movement a displacement of the array in the direction perpendicular to the medium might be useful, e.g. when parking the array. The maximum lateral scan excursion of a tip depends on the dimension of a single storage field. In the present example, the maximum scan excursion may be $\geq 30 \mu\text{m}$. Using
25 known x-y positioning means, an access time in the range of 1 ms to 1 μs can be achieved. This compares very favorably with present day disc drive access times of about 10 ms. In case of a storage system as illustrated in Figure 7, a total data rate of 100 Mbits/s can be obtained (assuming 10^6 bits/storage field, 1000 fields and 100kHz scan speed), of course, these
30 numbers scale with the the scan speed and the number of storage fields.

In the following the process of writing information is outlined:

- 1 1. In order to record (WRITE) information in a storage medium according to the present invention, suited pulses are fed to a local probe used for writing information.
- 5 2. These pulses affect a deflection of the local probe such that an indent is formed in that the probe is pressed against said storage medium.
3. A sequence of indents is written if said probe is scanned across the medium.

10

Information stored in form of indents can be retrieved as follows:

1. Either the local probe used for the recording of information or another probe is scanned across the storage medium or section of the storage medium where the respective information is stored.
- 15 2. The local probe is scanned across the storage medium such that an output signal is provided which can be used to detect an indent or sequence of indents.

20

It is important that the temperature of the system is kept below the transformation temperature T_c of the SMA used, because otherwise information may be deleted or modified.

- 25 Information can be deleted in a selective manner, e.g. bit-by-bit, by carrying out the following steps:

1. Identifying an indent in the present storage medium which is to be deleted,
- 30 2. positioning a heat source such that this indent and/or the surrounding medium can be heated,

- 1 3. applying a signal of appropriate amplitude and duration to said heat
 source such that this indent and/or the surrounding medium is heated
 to the transformation temperature T_c or above so as to return into its
 Martensite form.

5

 As mentioned above, the heat pulse can either come from a light source,
 such as a semiconductor laser, emitting light at a wavelength suited for
 locally heating said storage medium, or a local probe with means for direct
 or indirect heating can be employed. For direct heating, the cantilever
10 carrying the probe may comprise a metallization for electrically heating the
 probe. The heat may be generated by a voltage drop at a resistor formed in
 or at the cantilever. Instead, the local probe may be indirectly heated using
 incident light from a light source. Depending on the process used for
 transferring the heat from the heat source to the storage medium, the scan
15 speed has to be controlled. The faster the storage medium can be locally
 heated, the faster information can be erased because the heat source can
 be scanned across the medium faster.

 In the erase mode the heat source can either be scanned continuously
20 across the medium, or the heat source may be moved step-by-step. If
 moved step-by-step, the duration needed for locally heating the medium
 defines how long the heat source has to be stopped while heating. The heat
 source's inertia defines how long it takes to bring it up to speed again. Both
 together defines the average scan speed which can be obtained while
25 erasing information.

 If one wants to erase the whole storage medium or whole storage fields,
 according to the present invention, it is advantageous to heat the whole
 storage, or the respective storage field only, such that its overall
30 temperature reaches the transformation temperature for a short period of
 time. All indents and other deformations are automatically removed because
 the shape memory alloy returns to its Martensite form.

CLAIMS

- 1
1. Storage medium for use in a scanning probe storage system comprising
a substrate (20; 30; 40; 50) carrying a shape memory alloy layer (24; 34;
5 44; 54.x), said storage medium being characterized in that said shape
memory alloy layer (24; 34; 44; 54.x) is chosen such that
- an indent (23; 33) can be formed by mechanically deforming said
shape memory alloy layer (24; 34; 44; 54.x), if a local probe of said
scanning probe system exerts pressure on said shape memory
10 alloy layer (24; 34; 44; 54.x), and
 - an indent (23; 33) can be removed by locally heating said shape
memory alloy layer (24; 34; 44; 54.x) to its transformation
temperature (T_c) or above.
- 15 2. The storage medium of claim 1, wherein said shape memory alloy layer
(24; 34) is the uppermost layer directly facing the local probe of said
scanning probe system.
3. The storage medium of claim 1, wherein said shape memory alloy layer
20 is covered by a layer which does not prevent a local probe of said
scanning probe system from deforming said shape memory alloy layer.
4. The storage medium of claim 1, wherein said layer covering said shape
memory alloy layer is a mono-layer of molecules serving as kind of a
25 lubricant reducing the friction between the local probe of said scanning
probe system and the storage medium.
5. The storage medium of claim 1, wherein said shape memory alloy layer
(24; 34; 44; 54.x) has a thickness of 1nm to 10 μ m, and preferably
30 between 10nm and 500nm.

- 1 6. The storage medium of claim 1, wherein said shape memory alloy layer (24; 34; 44; 54.x) comprises a binary, ternary, or quaternary composition of alloys.
- 5 7. The storage medium of claim 1, wherein said shape memory alloy layer (34) has a thickness such that said indent (33) extends through it into the substrate (30) underneath.
- 10 8. The storage medium of claim 7, wherein a soft layer (41) is situated between said shape memory alloy layer (44) and said substrate (40), said shape memory alloy layer (44) having a thickness such that said indent extends through it into said soft layer (41) underneath.
- 15 9. The storage medium of claim 1, comprising at least two storage fields each having at least a shape memory alloy layer (54.x), said substrate being a common substrate (50) carrying said storage fields.
- 20 10. Scanning probe storage system comprising a scanning probe or scanning probe array and a storage medium according to any of the preceding claims.
- 25 11. The scanning probe storage system of claim 10, wherein said local probe comprises means for exerting a pressure on said shape memory alloy layer in order to form an indent if an appropriate signal is applied.
12. The scanning probe storage system of claim 10, comprising means for scanning a local probe across said storage medium and means for detecting indents in said shape memory alloy layer.
- 30 13. The scanning probe storage system of claim 10, comprising a heat source for locally heating said shape memory alloy layer to its transformation temperature (T_c) or above such that an indent close to

- 1 the location being heated is removed if said shape memory alloy layer
returns into its Martensite form.
- 5 14. The scanning probe storage system of claim 10, wherein said heat
source is a local probe having means for directly or indirectly heating it.
- 15 15. The scanning probe storage system of claim 10, wherein said heat
source is a light source.
- 10 16. Method for erasing an indent being mechanically formed in a shape
memory alloy layer which is part of a storage medium, comprising the
steps:
- 15 a) positioning a heat source such that said shape memory alloy layer
at said indent to be deleted or close to it can be reached by the
heat delivered,
- b) driving said heat source by a signal such that said shape memory
alloy layer at said indent to be deleted or close to it is heated,
- 20 c) said signal having an amplitude and duration sufficient to locally
heat said shape memory alloy layer to its transformation
temperature or above.
17. The method of claim 15, whereby said heat source is continuously
scanned across said storage medium.
- 25 18. The method of claim 15, whereby said heat source is scanned across
said storage medium step-by-step, the scan movement being stopped
while said shape memory alloy layer is locally heated.
- 30 19. The method of claim 15, whereby all information stored on said storage
medium in form of indents can be deleted by heating the whole storage
medium or storage field such that said shape memory alloy reaches its
transformation temperature.

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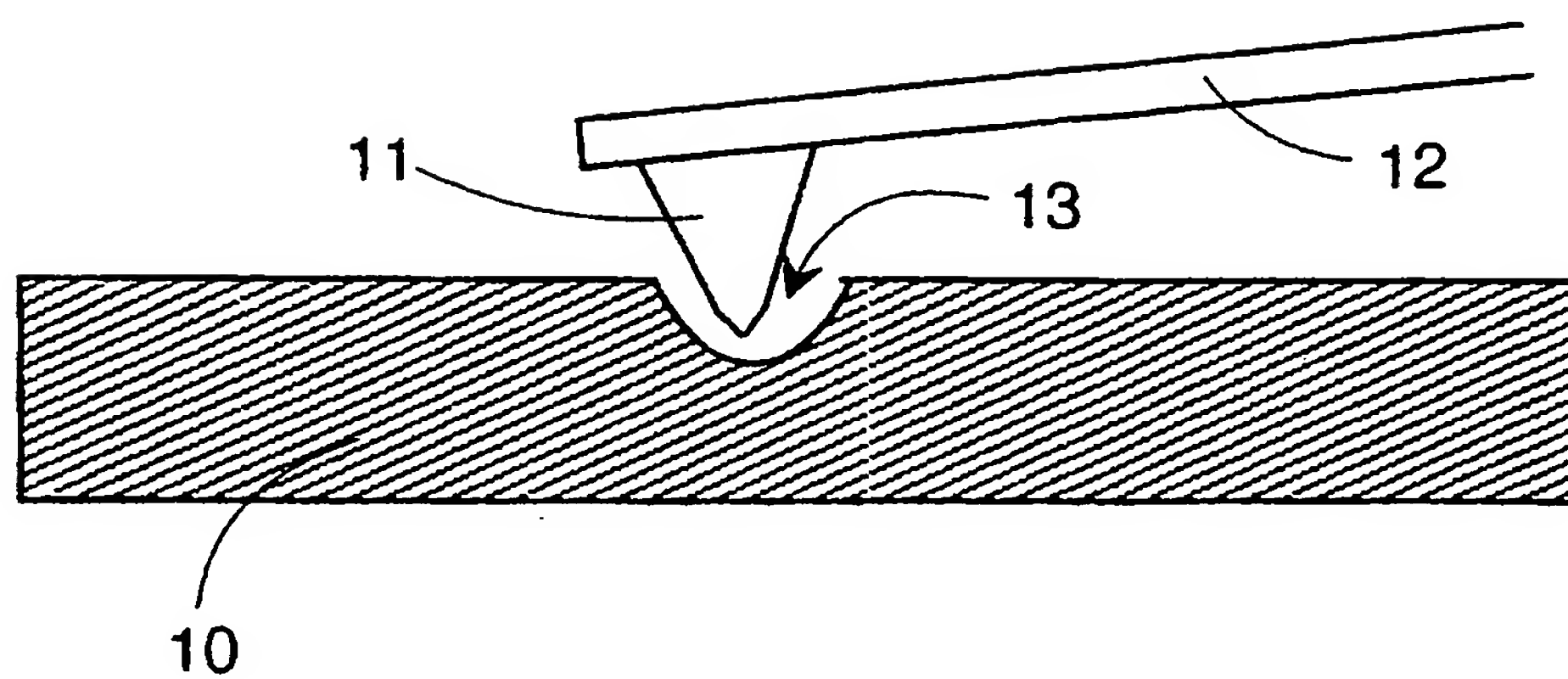


FIG. 1

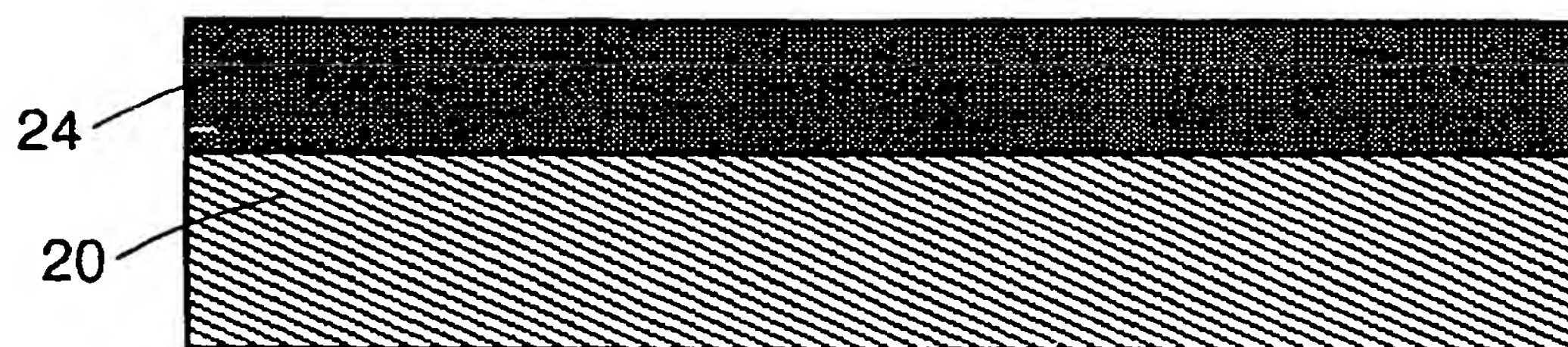
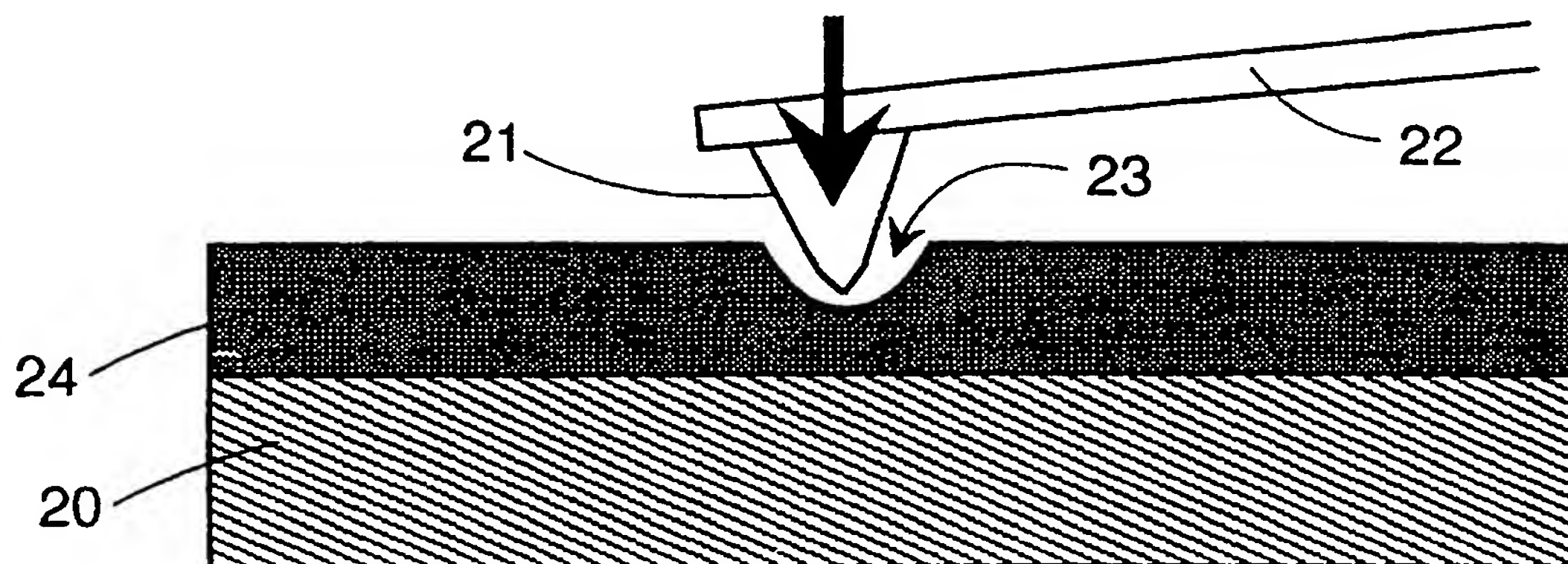


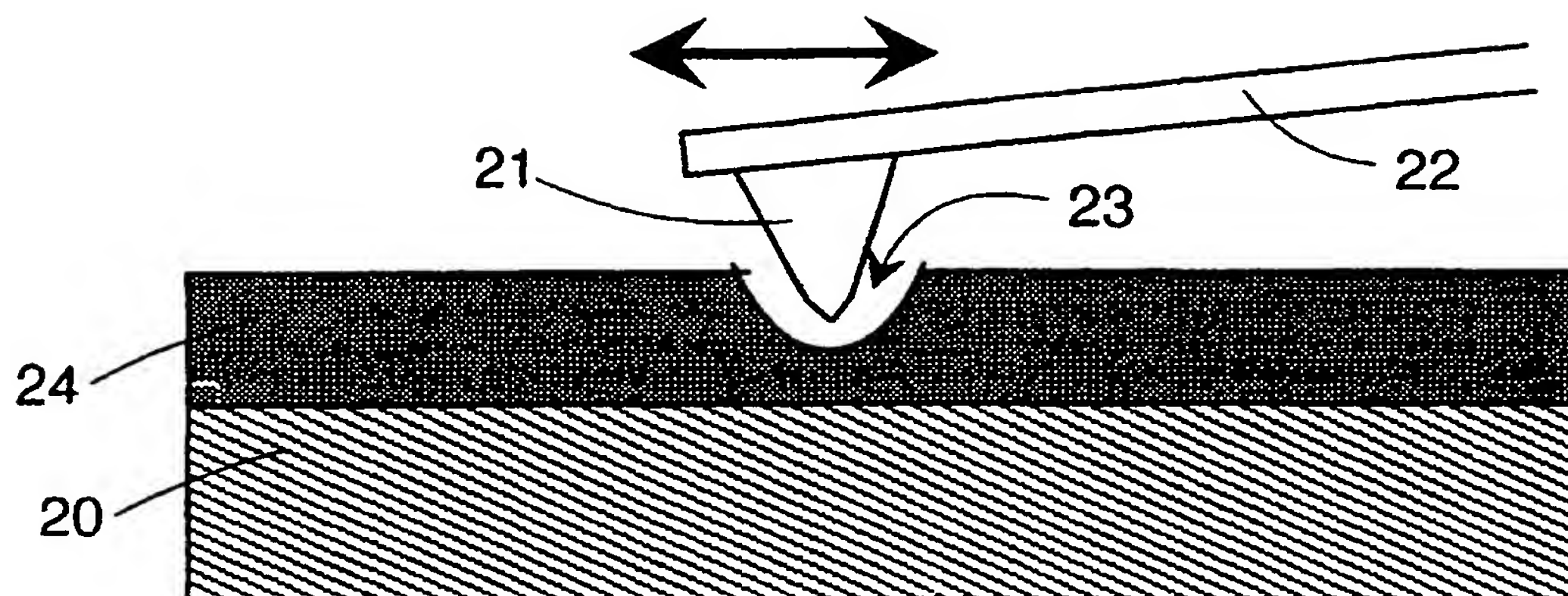
FIG. 2

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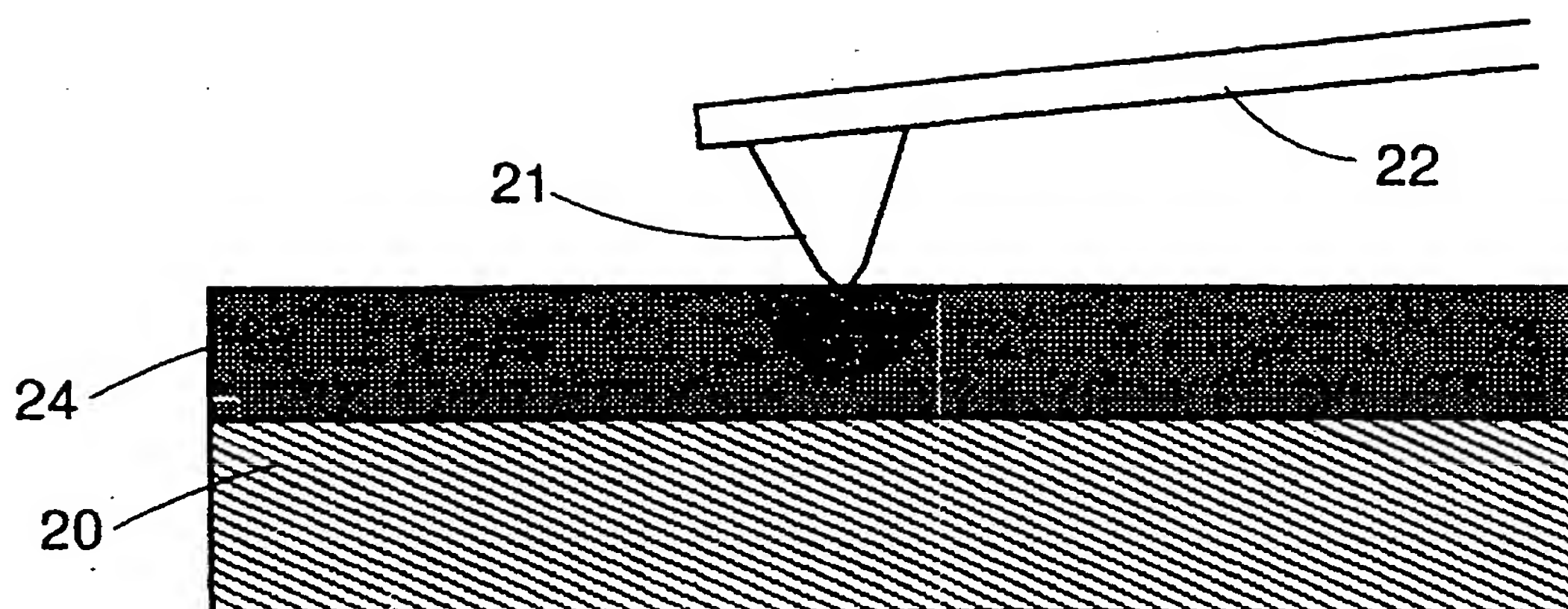
WRITE
($T < T_c$)

FIG. 3A



READ
($T < T_c$)

FIG. 3B



ERASE
($T > T_c$)

FIG. 3C

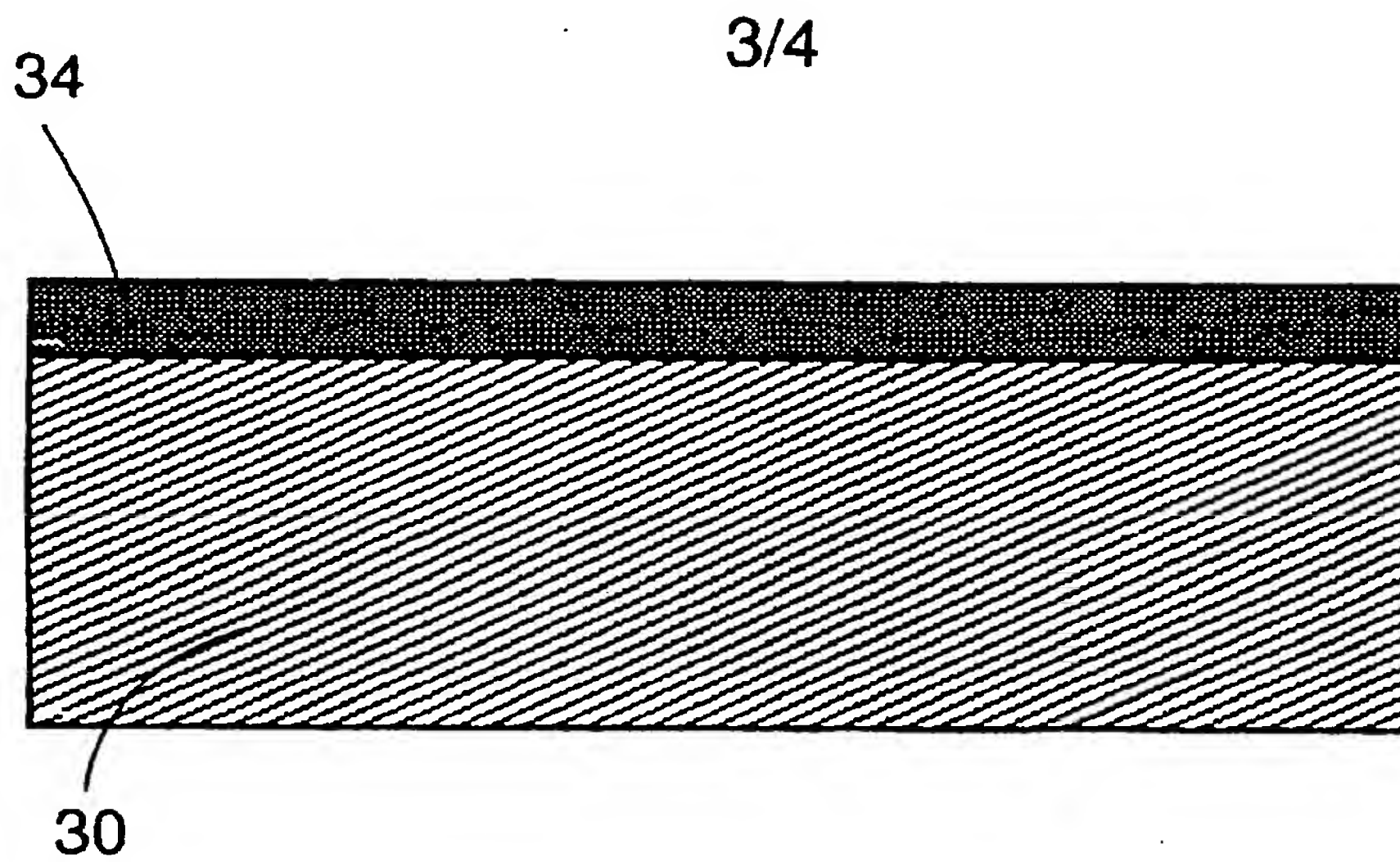


FIG. 4A

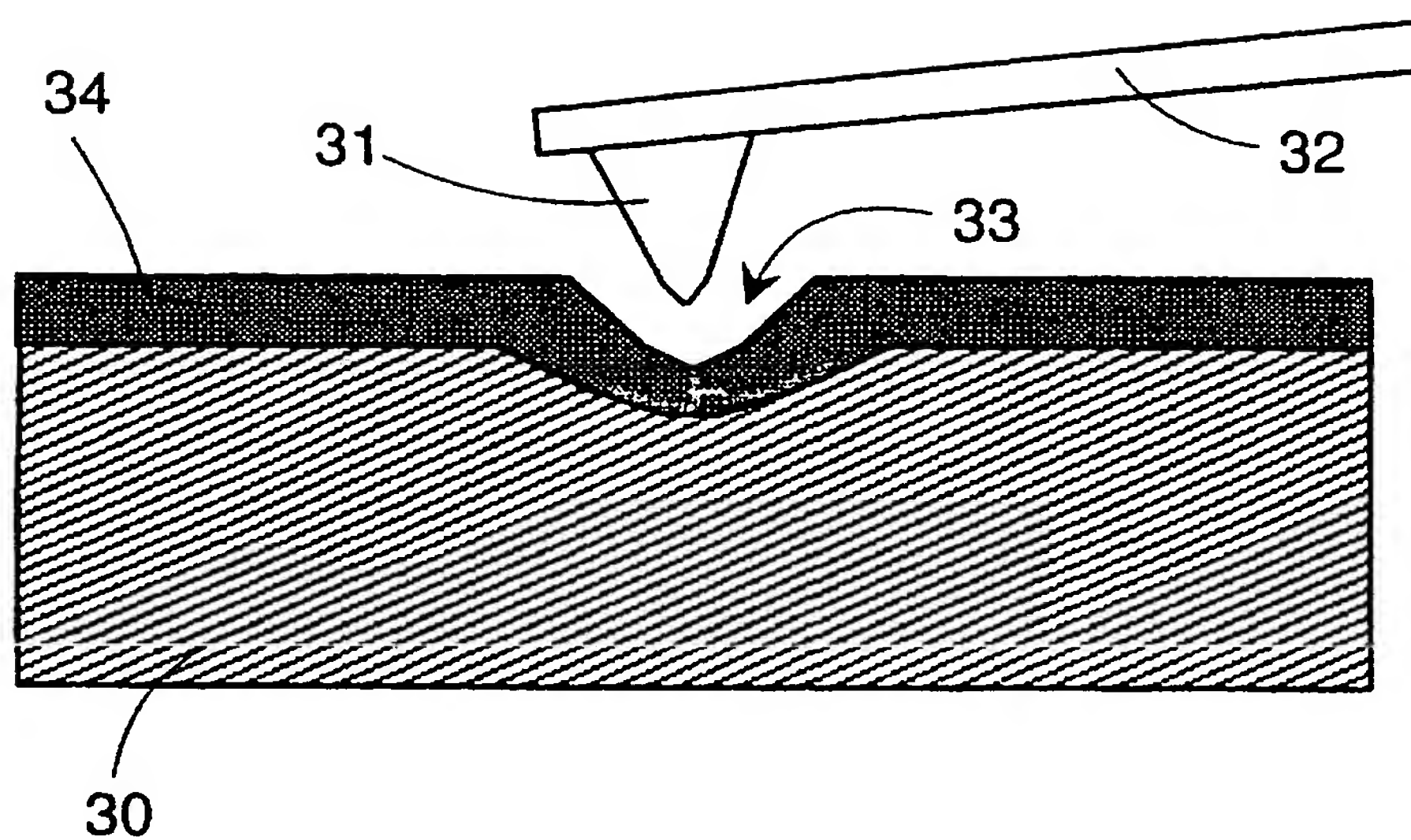


FIG. 4B

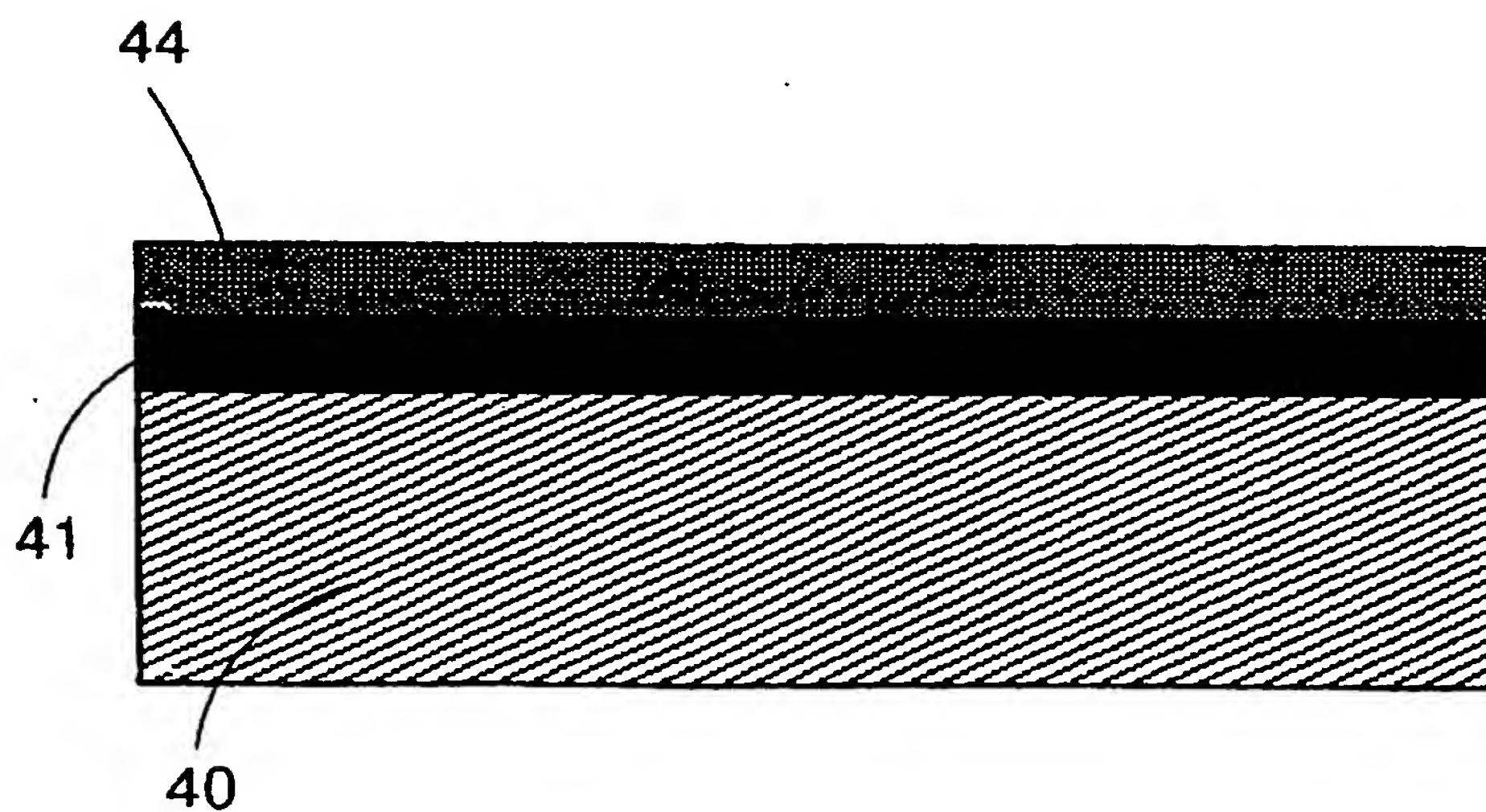


FIG. 5

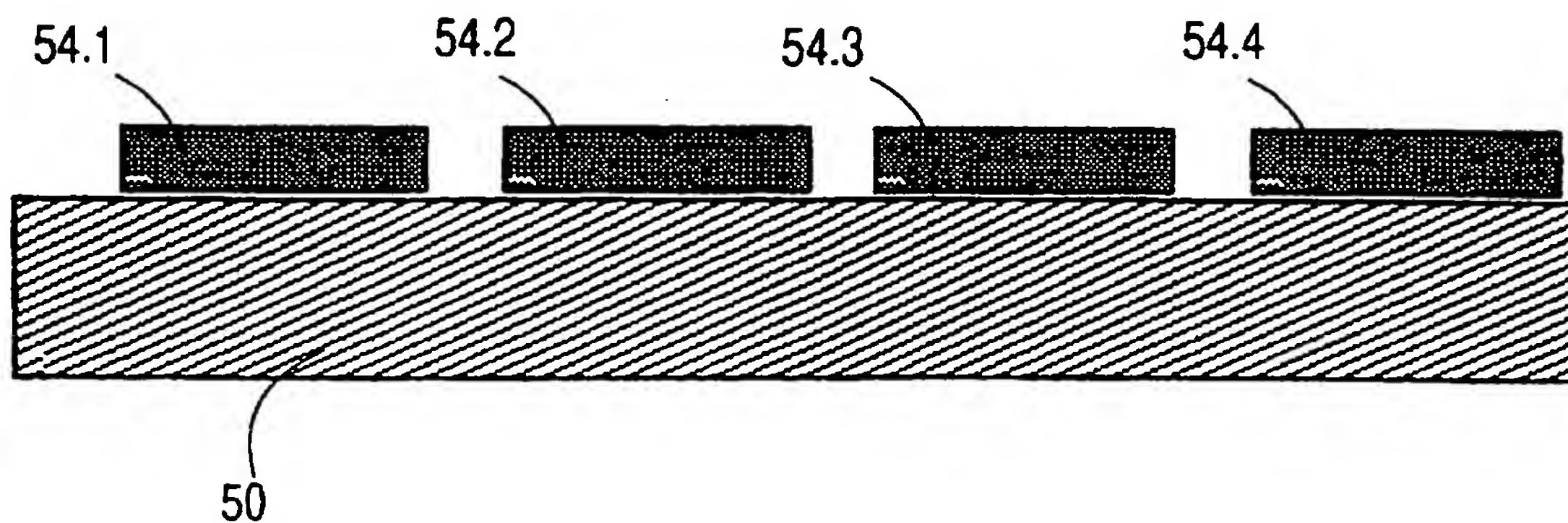


FIG. 6

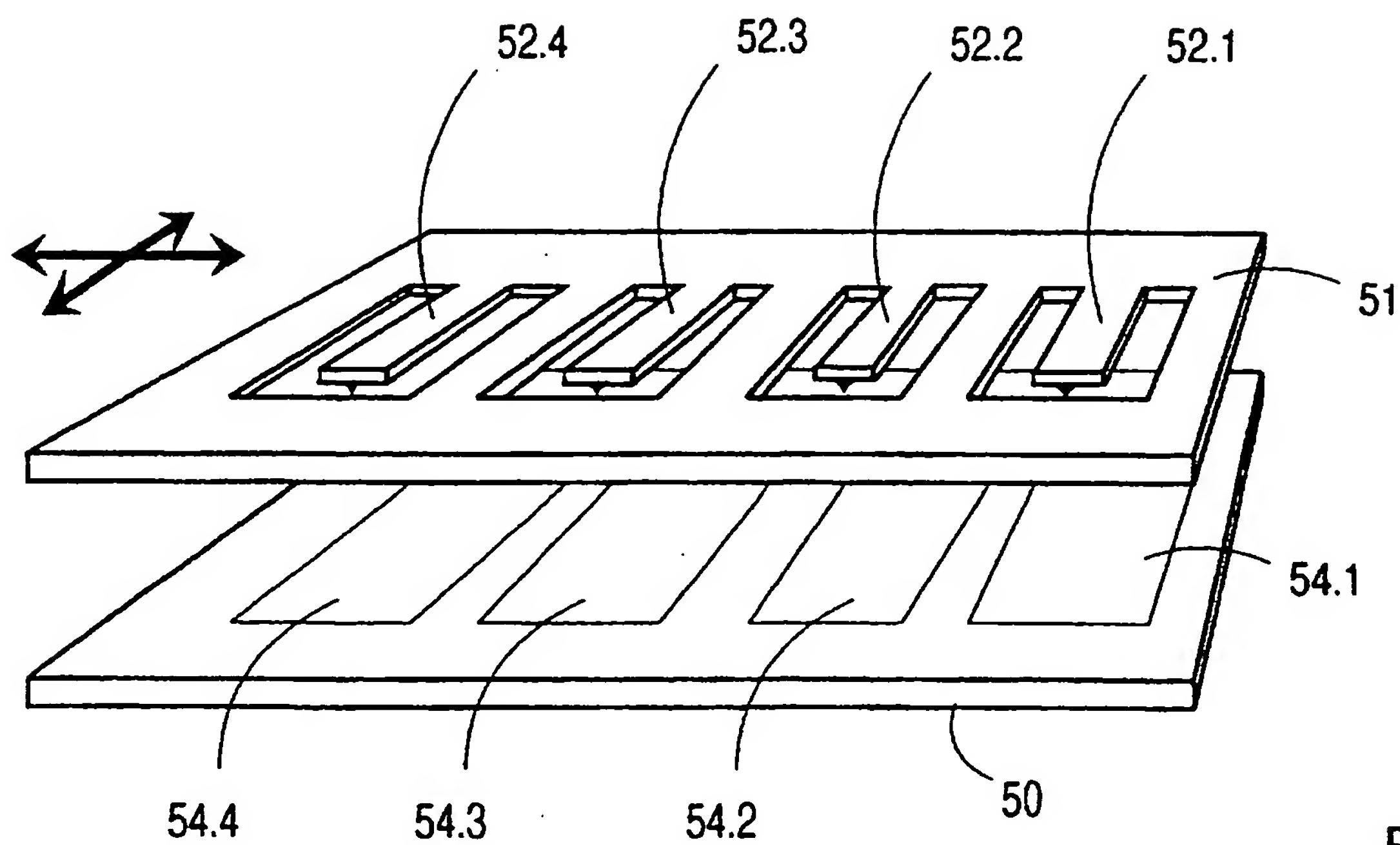


FIG. 7

INTERNATIONAL SEARCH REPORT

Int: mal Application No
PCT/IB 96/00472

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G11B3/00 G11B3/68 G11B11/16

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G11B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	PATENT ABSTRACTS OF JAPAN vol. 009, no. 236 (P-390) [1959] , 21 September 1985 & JP,A,60 089848 (MATSUSHITA DENKI SANGYO K. K.), 20 May 1985,	1,2,10
X A	see abstract; figure 3 see figures --- -/--	16 11,13, 15,19

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

4 December 1996

Date of mailing of the international search report

02.01.97

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Fux, J

INTERNATIONAL SEARCH REPORT

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	EP,A,0 360 337 (PHILIPS NV) 28 March 1990 see column 3, line 15 - line 32 see column 4, line 47 - line 57 see column 13, line 20 - line 27; figure 3C see column 11, line 50 - column 12, line 21 see column 11, line 15 - line 24 see column 9, line 55 - column 10, line 11; figure 3C	1,2,10 11,12
A	--- EP,A,0 568 753 (IBM) 10 November 1993 see column 5, line 3 - line 15 see column 5, line 29 - line 51 see column 6, line 54 - column 7, line 28 see column 7, line 52 - column 8, line 27; figures 1,2	1,2, 9-16,19
A	--- EP,A,0 665 541 (MATSUSHITA ELECTRIC IND CO LTD) 2 August 1995 see column 21, line 41 - line 52 see column 22, line 24 - column 24, line 1; figures 7-9	1,2,6, 10-15
A	--- EP,A,0 184 189 (HITACHI LTD) 11 June 1986 see page 9, line 27 - page 10, line 17 see page 12, line 24 - line 27 see page 13, line 8 - page 15, line 22; figures 4A,4B,5,6	1-3,5, 10,13-15
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A	--- PATENT ABSTRACTS OF JAPAN vol. 016, no. 041 (M-1206), 31 January 1992 & JP,A,03 247496 (OMRON CORP), 5 November 1991, see abstract	1
2 4 A	--- EP,A,0 404 333 (DIGITAL EQUIPMENT CORP) 27 December 1990 see column 2, line 31 - line 53 see column 5, line 24 - line 32 --- -/-	4

INTERNATIONAL SEARCH REPORT

International Application No
PCT/IB 96/00472

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	PATENT ABSTRACTS OF JAPAN vol. 007, no. 127 (P-201), 3 June 1983 & JP,A,58 045601 (YOSHIHIRO NAKAHARA), 16 March 1983, see abstract	
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information on patent family members

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PCT/IB 96/00472

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DE-A-1522989	16-10-69	NONE	

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